The Future of Nonvolatile Memories

T.Mikolajick and C.U. Pinnow

Infineon Technologies MP TI TD INN, Balanstrasse 73 81541 Munich, Germany
Thomas.Mikolajick@infineon.com

Driven by an increasing demand for mobile devices, the market for nonvolatile memories is rapidly growing [1]. Today all nonvolatile memories are based on charge storage and are fabricated by materials available in CMOS processes. These devices have some general shortcomings like slow programming (from microseconds up to milliseconds), limited endurance (typically 10^5 – 10^6 write/erase cycles) as well as the need for high voltages (10-20V) during programming and erase. These shortcomings imply some severe restrictions on the system design side. A memory that could work like a random access memory (similar to DRAM or SRAM) and would be nonvolatile, would therefore greatly simplify system design, since one universal memory could be used, where two or three memories are required today. To achieve this goal, new materials that enable new switching mechanisms have to be introduced into the CMOS process flow. For many years a number of approaches based on switching in inorganic materials are widely examined. The most prominent ones are ferroelectric memories, magnetoresistive memories and phase change memories. Ferroelectric Memories use the two stable polarization values at zero bias to store a bit [2]. A variety of different approaches for magnetoresistive memories exist [3]. For high density applications magnetic tunnel junctions are the only approach to offer the appropriate features with respect to available signal and cell resistance. Finally, phase change memories are based on the reversible phase transformations of a chalcogenide material between a high resistive amorphous and a low resistive crystalline state [4]. Recently another concept based on an electrochemical silver deposition in a miniaturized electrochemical cell has been developed [5]. Besides the integration of inorganic materials, also organic materials are discussed for future memory devices. Polymer memories use the bulk properties of inorganic materials which can be either resistance switching or ferroelectric switching. Polymer memories could open the path to a class of memories that have densities between current semiconductor memories and hard disk drives by stacking several memory layers on top of each other. Moreover, one can envision that also the support circuitry may be fabricated in polymer technology leading to drastically reduced production costs. Finally, effects in single molecules can be used to create molecular memory devices [6]. Again it can be envisioned, that these devices open the path to a completely new integration scheme using also molecular support devices. Starting with a review of current nonvolatile memories, advantages and drawbacks of the above mentioned emerging memory concepts will be discussed.

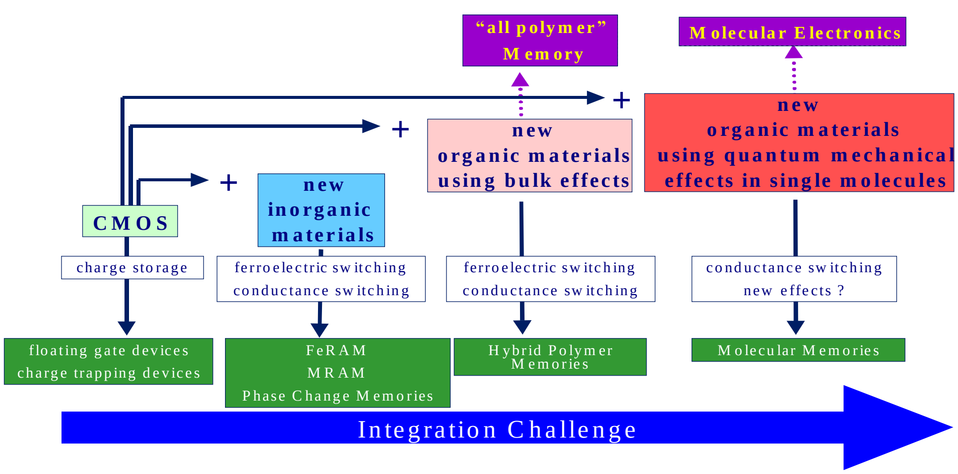

Fig. 1 Hierarchy of options for today's and future nonvolatile memories

References

[1] A. Niebel, Fash memory `Comes of Age`- Creating ist own Markets: Flash Application Market Forcast through 2004, Non-Volatile Semiconductor Memory Workshop, Feb 13th-16th, 2000
[2] T. Mikolajick et al., FeRAM Technology for High Density Applications, Microelectronics Reliability Vol.41/7, 2001, S.947-950
[3] S. Tehrani et al, Progress and Outlook for MRAM Technology, IEE Trans. On Magn. Vol. 35, No. 5, 1999
[4] S. Lai and T. Lowrey, OUM – a 180nm Nonvolatile Memory Cell Element Technology for Standalone and Embedded Applications, IEDM technical digest, 2002
[5] R. Neale, Micron to look again at non-volatile amorphous memory, electronic engineering design, April 2002
[6] M.A. Reed et. Al., Prospects for Molecular-Scale Devices, IEDM technical digest, 1999